Polymeric Fasteners Feasibility Study

Erik Dambach, 2003 NASA Academy Research Associate

Dartmouth College, Hanover, NH

Principal Investigator: Scott Hull, Code 591

NASA Goddard Space Flight Center

Greenbelt, MD 20771

Introduction

The feasibility study is being conducted in order to determine whether or not polymeric bolts can be used as fasteners on spacecraft, which are typically held together with corrosion resistant steel (CRES) bolts. Steel often melts at about 1370°C. As the spacecraft reenters the earth's atmosphere, the steel bolts hold the aluminum body together while the aluminum begins to demise. Polymeric bolts have melting points around 250°C. The plastic bolts are expected to melt quickly, allowing the spacecraft to break apart at a much higher altitude, and, hopefully, providing the components of the spacecraft more time to fully demise.

¼-20 Hex Bolt Materials

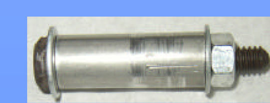
- Amodel AS-1133 HS
- Lutrel GP-2306F
- Nylene 5133HSL
- PEI-GP30-NAT-BX50
- QR-1310 IM-GF30
- Reny PAMXD6 1002F
- Ryton R-4
- Ultem 1000
- Ultem 2300

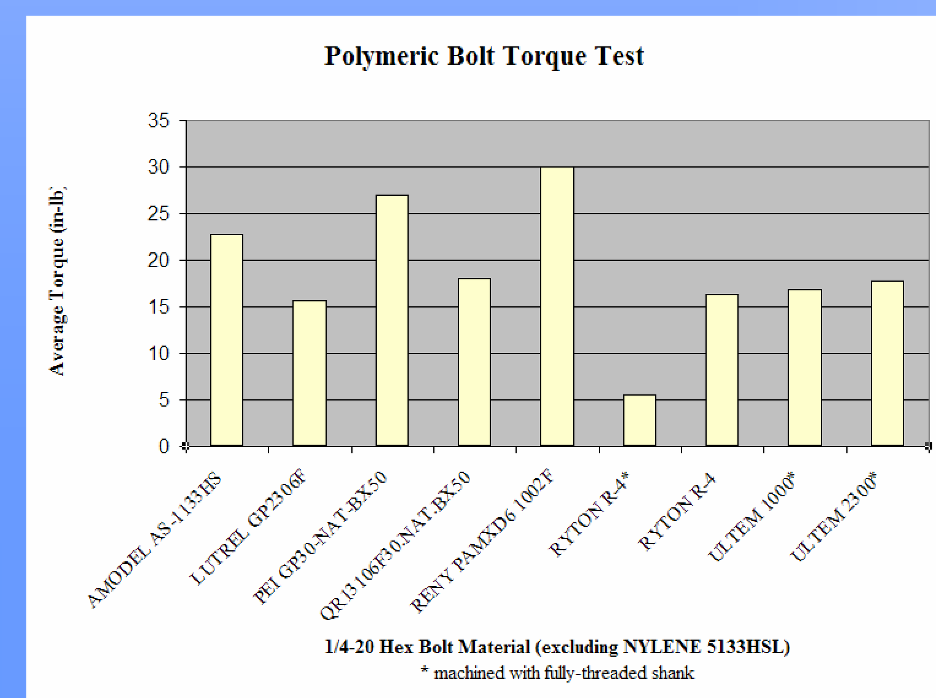
Testing

- Torque test (completed)
- Longitudinal cross-sections of each bolt (in progress)
- Tensile tests at room temperature and -20°C (planned)
- Shear tests at room temperature and -20°C (planned)
- ORSAT simulations - reentry analysis for each bolt material compared to steel (in progress)

Torque Test

The test was performed to obtain an understanding of the applied torque required to break the bolts.





A torque wrench in the 1-100 in-lb range with 25% uncertainty was rotated counter-clockwise constantly until the bolt broke. Ten runs were performed for each type of bolt. The highest and lowest values were discarded, and the remaining eight were used to calculate the average torque. Reny PAMXD6 1002F was found to be able to withstand the greatest average torque.

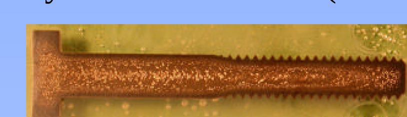
Longitudinal Cross-sections

Discovery of Voids in Molded Samples

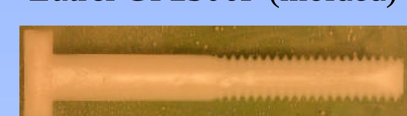
Amodel AS-1133 HS (molded)

Remy PAMXD6 1002F (molded)

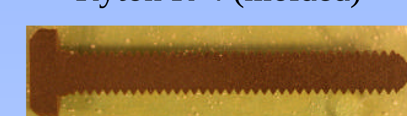
Lutrel GP2306F (molded)



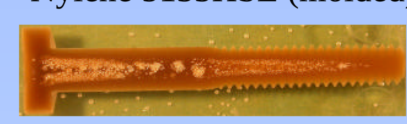
Ryton R-4 (molded)



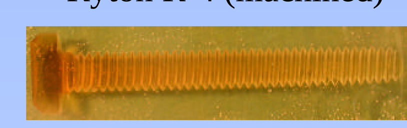
Nylene 5133HSL (molded)



Ryton R-4 (machined)

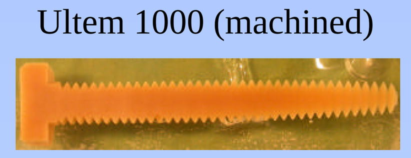


PEI GP30-NAT-BX50 (molded)



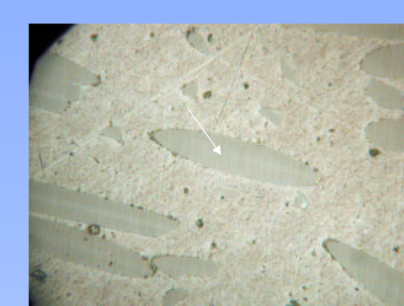
Ultem 1000 (machined)

QR-1310 IM-GF30 (molded)

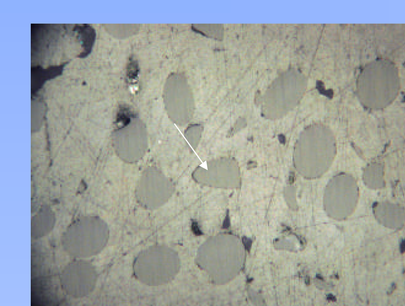


Ultem 2300 (machined)

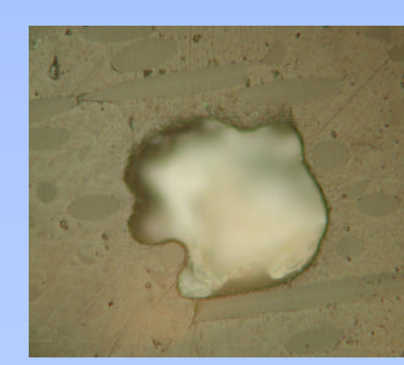
Investigation of Glass Fill in Ryton R-4 Using Inverted Stage Microscope with 40x Magnification



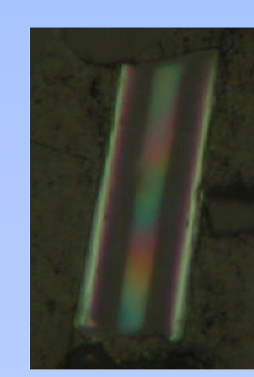
Molded - glass fibers



Machined – glass balls



Flow of glass fibers around void



Glass fiber

Tensile and Shear Tests Using Instron

Set-up for Room Temperature

Set-up for -20°C

Conclusion

Once the testing has been completed and the data analyzed, the findings will be presented to Michael Adams in the Mechanical Engineering Branch with the hypothetical situation: steel and titanium bolts no longer exist, can you use these plastic ones? Creative mounting ideas to lessen the strain on the plastic bolts, such as using shear pins or leveraged mounting arms, will need to be considered at this stage. The next course of action will depend upon his response, as his expert opinion will be used to determine if polymeric fasteners are feasible when considering spacecraft construction. Should Mr. Adams validate them, the bolts will need to satisfy the requirements as described in 541-PG-8072.1.2 – *Goddard Space Flight Center Fastener Integrity Requirements*.

Acknowledgements

Scott Hull, Code 591
Code 541 Materials Engineering Branch
Code 562 Parts, Packaging, and Assembly Technologies Office
Michael Adams, Code 543
David Wisniewski, World Class Plastics, Inc.
New Hampshire Space Grant Consortium

17 July 2003